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GUTTA-PERCHA.

By B. H. F. Barnard.
Deputy Conservator of Forests, Perak.

THE product known as gutta-percha first attracted attention in Europe about the year 1843, when samples were sent to England from Singapore.

It has been suggested that "gutta" is the Latin word *gutta* (= a drop) introduced through the Portuguese, and that it was adopted by Malays in the form "getah." It seems more probable that "getah" is a Malay word, and that the Latin spelling was adopted as a convenient form of transliteration. "Getah" is applied by Malays to any liquid exudation from a tree. "Percha" refers to the supposed source of origin—*i.e.*, Pulau Percha, the Island of Sumatra.

Botanical Classification.

It was first described as "wood" and was known as "mazer wood." It is difficult now to understand how such a mistake can have occurred, but it is to be presumed that those who were responsible for it could have known only that it was the product of a tree, but could have had no knowledge of the method of production. It is remarkable that such authorities as Sir William Hooker and the Tradescants should have fallen into this error. The tree from which these samples were obtained was first described by Hooker, and was placed by him in the genus *Isonandra* of the natural order *Sapotaceæ*. Further investigation, however, led to its being assigned to the genus *Dichopsis* by Bentham and to that of *Palaquium* by Burck, and it is by the latter name that the majority of trees which produce the most commercially valuable gutta-percha are now known. The genus has been divided into many species. The original trees found on the Island of Singapore were given the name of *Palaquium Gutta*. The two species which are commonest in the Federated Malay States are *P. oblongifolium*, and *P. obovatum*, of which the former is hardly distinguishable from *P. gutta*, and is not improbably merely a local variety. *P. oblongifolium* is much superior to *P. obovatum*, the gutta which it produces being regarded commercially as of the highest quality. The inferiority of *P. obovatum* is due to the high percentage of resin which it contains. Other species which produce gutta of good quality are *P. borneense* and

P. Treubii, neither of which is known to occur in any quantity in the Malay States. There are also a few other species, but they are either of inferior quality, or of rare occurrence. Gutta-percha is known generally to Malays as *taban*, *P. oblongifolium* being distinguished as *taban merah*, and *P. obovatum* as *taban puteh*. The term *taban setra* is often applied to *P. oblongifolium*, but it is merely a trade name for gutta of good quality, and may also be applied to *getah sundik*, which is obtained from *Payena Leerii*. Commercially guttas are graded according to the supposed sources of their origin, and that which is known as Pahang gutta is considered the best. This is undoubtedly the product of *P. oblongifolium*, which is not confined to the State of Pahang, but is common in many parts of the Federated Malay States.

Distribution and early History.

The geographical distribution of true gutta-producing trees is limited to the area comprising the Malay Peninsula as far north as Kedah and Kelantan, the islands of Sumatra, and Borneo, and all the smaller islands lying between them. From this area alone has been obtained all the gutta-percha which has been used in the past, and upon this source depends the natural supply of the future. In the year 1902 the Secretary of State for the Colonies in a special despatch drew the attention of the Local Government to the great importance of gutta-percha, and to the necessity for taking steps to assure supplies. Some years previously the felling of *taban* trees was prohibited, but the prohibition was never very effectual. For many years parties of Malays and Dyaks roamed the country felling every tree they found, which exceeded four or five inches in diameter. The more accessible parts of the country had been cleared of trees before felling was prohibited, and it was practically impossible to enforce the regulation effectively in the remote districts. Fortunately trees of less than four or five inches in diameter were of no use to the collectors. It is the young trees thus left upon which we are now relying to restock our forests.

General Description.

Gutta-percha is not infrequently confused with rubber. In appearance the two products are much alike, when in the form of latex, and in a general way they are obtained from the tree in the same manner, but there the similarity ends. The latex of gutta coagulates and dries more quickly than that of rubber on exposure to the air. The time required for coagulation varies in the different species: it is rapid in the case of *P. oblongifolium*, small quantities of which coagulate and harden after contact with the air for a few minutes. The most obvious difference between gutta and rubber is that the former is only slightly elastic; it does not, as does rubber, derive its chief value from its elasticity. One of its most valuable properties is that it becomes soft on being subjected to moderate heat without losing its other physical characteristics. At a

temperature of 140° Fahrenheit it becomes plastic, having about the same consistence as glaziers' putty, but having none of the stickiness of that material. On cooling it hardens and retains any shape given to it while in the plastic state.

Uses.

As regards the uses to which gutta-percha is put, by far the most important is the insulation of submarine and underground electric cables. Many other substances have been tried, but nothing has yet been discovered which gives such satisfactory results, and hitherto it has been practically the only material used in the construction of all the submarine cables that have ever been laid. It will be seen from this statement how very important it is that steps should be taken to ensure the supplies of the future. The quantity required for the maintenance of cables is not large, but, tough as gutta-percha is, it is not indestructible, and in course of time the insulating covers have to be renewed. In spite of the introduction of wireless telegraphy new cables are constantly being laid, and those who are in the best position to judge do not anticipate that wireless will ever entirely supersede cable telegraphy, owing to the difficulty of obtaining secrecy by the former method. Within the British Empire the responsibility of maintaining supplies falls entirely upon the Malay States and North Borneo. About three quarters of the gutta-percha-producing area of the world is under Dutch control, the remaining quarter being British.

Gutta is also largely used in the manufacture of surgical appliances, funnels, bottles, and other articles which are employed in frequent contact with acids, its resistance to acids and the ease with which it can be completely sterilized, being among its most valuable properties.

It is suitable for many other purposes, but its use has always been limited by the uncertainty of the supply. A form in which it is familiar to the general public is the outer cover of golf balls.

Distribution in the Federated Malay States.

Taban is found in varying quantities in nearly all parts of the Federation. *Taban merah* in any abundance is confined to land below an elevation of about 600 feet; it is at its best on flat but well-drained land below that level and on the lower slopes of hills. *Taban puteh* is equally common, but it is usually found at a slightly higher elevation on the hills. It should not be concluded from this that the higher situation and the poorer soil are actually more favourable to the growth of *taban puteh* than the richer soil of the foothills. A more reasonable inference is that it has a greater capacity for withstanding the disadvantages of the drier situation than have other trees with which it is associated, and is thus able to establish itself more easily. Neither *taban merah* nor *taban puteh* is found on land which has not good drainage. In general habit the two species are very alike.

As regards size, Mr. L. Wray, late Curator of the Perak Museum, in a report on Gutta-Percha written in 1883, says that *P. Gutta* attains a diameter of four or five feet, and a height of between 100 and 200 feet. I have never seen or heard of a tree reaching these dimensions, but it may be that in favourable situations they do occur. Wray is an authority whose statements are entitled to respect: moreover, at the time when he wrote the general clearance of old trees had not been completely effected. A tree having a girth measurement of five feet at a height of four and a half feet from the ground is now considered a big tree.

The leaves are subject to considerable variation in their form, and judging from the appearance of the leaves only it is not possible to determine the species with certainty. In cases of doubt between *taban merah* and *taban puteh* the point can be settled by tearing a leaf or twig slowly, when, in the case of *taban merah*, fine threads of gutta will be drawn out between the two pieces: this does not occur in *taban puteh*. As with most other trees the leaves of both species are usually much larger on young than on old plants. The leaf of *taban merah* is sharply acuminate; the under side is of a golden brown colour and is of silky texture due to a covering of fine hairs; the lateral veins number about 28 on either side of the mid-rib, and are set nearly at right angles to it. The *taban puteh* leaf is blunt and has also the golden brown lower surface, but it is coarser in texture than that of *taban merah*; the veins are fewer in number, and are at an acuter angle with the mid-rib; they are also very much more prominent. The flowers do not exceed an eighth of an inch in diameter, and are sessile towards the ends of the branches and twigs. There are two flowering seasons in the year. The first occurs in March or April, the fruit ripening in July and August; the second occurs in September or October, the fruit ripening in January and February. Trees do not fruit regularly every year, and the quantity of the crop varies considerably. *Taban* has been known to bear fruit at 15 years of age, but it does not usually bear heavily until later in life.

The rate of growth of the trees is usually slow until about the sixth year, when it will be about six inches in girth; after that age, in favourable circumstances, it increases in girth annually by about one and a half inches up to the 14th year, from which time the rate of growth increases from two to three inches a year, the tree reaching a girth of five feet in 30 to 35 years.

Methods of Extraction.

As in the case of rubber, the latex is found in the inner layers of the bark of the tree, the quantity increasing as the cambium is approached. It is also present in the leaves of the tree. In the days of unrestricted collection the method employed was that of felling of the trees and cutting rings round the stem at intervals of about one foot. The cuts were made with a gouge about three

quarters of an inch in width, and penetrated to the wood. Cups made of leaves were placed beneath each cut to catch the gutta. In the case of *taban puteh* and some other kinds a considerable quantity of gutta dropped into the cups, but *taban merah* coagulated for the most part in the cuts, very little reaching the cups. For inferior kinds a coagulant was sometimes required, and this was supplied by a decoction of the bark of a tree known as *Samak* (*Eugenia* sp.). A sufficient quantity of coagulated gutta having been collected it was heated in boiling water and pressed into any convenient shape. The amounts recorded as having been obtained in this way appear to have varied considerably. Wray states that he collected 2 lbs. 5 oz. from a full grown *P. oblongifolium*. There are no authentic records from which reliable averages of the yield from any one species can be computed. From accounts of individual experiments it is probable that a *P. oblongifolium* 40 inches in girth produced about $1\frac{1}{2}$ lbs. of clean gutta at one tapping.

Tapping.

Attempts have been made from time to time to take the latex from the stem of the living tree, but they appear to have met with very little success in the early days, and the idea appears to have been abandoned as impracticable. Experiments have been made during the last few years in the Federated Malay States, and the results obtained so far are encouraging. The tapping methods used in the rubber industry cannot be employed on account of the fact that the latex having been drawn off from a certain area of bark by a single cut, it is only slowly replaced by fresh latex, with the result that a cut yields nothing if opened a second time. The latex also coagulates rapidly on exposure to the air and seals up the end of the tubes that have been cut.

In tapping the living tree, the following method is adopted. A ladder, consisting of a single pole with cross pieces, is lashed to the trunk of the tree. Cuts are made into the bark at an angle of 45° to the axis of the tree over the whole stem and on the main branches. Any number of these cuts may be joined by a vertical cut: this is a matter of convenience on each individual tree. Hitherto cuts have been made at intervals of from 8 to 12 inches on two sides of the tree, the cuts being so arranged as to leave a strip of untapped bark on either side of the tree, each strip being about four inches in width. The cut should reach the inner layer of the bark, but should not penetrate the wood. The regulation of the depth of the cut is difficult owing to variations in the thickness of the bark, and the impossibility of complete supervision. As the tapping is not confined to that part of the tree which is near the ground, ladders are necessary, and the tapper is usually working in an uncomfortable and strained position, so that some latitude must be allowed both in the placing of the cuts, and in the depth to which they penetrate. The greater portion of the latex coagulates in the cuts, but some of it may run down the lateral into the vertical cuts, where it is collected

by means of a small tin cup stuck into the bark. The cups are put into the bark at intervals as may be found necessary. In the case of *P. oblongifolium* cups of two inches diameter and one and a half inches deep are large enough. *P. obovatum* flows more freely and in greater quantities, and therefore requires larger cups. When collecting the gutta from the cuts, the tapper scrapes out a small quantity with his knife and works it into a ball: this ball is then pressed into the cut and rolled along it, collecting gutta as it goes after the manner of a snowball. Having been rolled along several cuts, the ball assumes the shape of a flat disc, the gutta being always collected on the edge. The same disc may be used until it gets too wide at the edge to fit into the cuts, when a new one is started. The details of the operation are rather a matter for the individual fancy of the tapper. Gutta is collected several times at one tapping from the same cut. Each time the ball or disc is rolled along the cut, the removal of the gutta re-opens the cut ends of the latex tubes, and the flow commences again. The process is continued until the flow ceases. The tapper carries a basket as he climbs, in which he keeps his tin cups and the collected gutta.

In collecting from the living tree it is very noticeable that considerably more gutta is obtained from the upper portion of the stem and from the branches than from the lower part of the stem. This very important point appears to have escaped the notice of early experimenters, and the fact that it did so goes a long way to explain their failures. The distance apart at which the lateral cuts should be placed is probably about 12 inches. It is possible that cuts further apart will completely drain the intervening bark: further observation is required on this point. It is, of course, desirable, both for the sake of the tree and for the sake of economy in labour, that as few cuts should be made as will yield a reasonable outturn of gutta.

The weather and the time of collection are factors which have marked effects on the results. In wet weather the latex flows much more freely than in times of drought, when it becomes turgid, sometimes to the extent that it will not flow at all. Early or late tapping has the same effect. The greater quantity of water present in the tree in the early morning keeps the gutta in a liquid state. As evaporation proceeds during the day the gutta thickens and eventually ceases to flow. It is, as might be expected, also noticeable that the flow is maintained till a later hour on dull and sunless days. From the foregoing it will be obvious that, to be successful, it is necessary that tapping should begin directly it is light enough for the tappers to work. They should leave their lines before it is light. The tapping is usually finished by 11 a.m., and the gutta is then taken to the store and roughly cleaned, each tapper being responsible for his own collection. Before returning to the store the trees to be tapped the next day are selected and the ladders fixed to

them, so that the early hours of the day may not be wasted. The cleaning process is effected by immersing the gutta in hot water, when it quickly becomes plastic, in which state it can be worked with the hands and the greater part of the bark and dirt removed. While soft it may be pressed into any convenient shape for storing. The cleaning process gives the gutta a very much better appearance, and it is also of advantage in that it puts it into a form in which less of its surface is exposed to the air. In the rough state, that is in discs and scraps as picked from the cuts, it is liable to deteriorate by oxidization. The clean gutta is kept in the best condition if stored submerged in water.

Both *P. oblongifolium* and *P. obovatum* are treated in the same way, but care should be taken to prevent the two species being mixed. The value of *P. oblongifolium* is, of course, greatly decreased by adulteration with the inferior species. Moreover, if further experiments are successful, it is important that the gutta which is to be put on the market in this form should be recognized from the outset as being of the best quality, and that its good name should not be endangered by adulterated lots being offered for sale under the same mark.

The knife which has proved to be the most generally convenient is one of the pattern known as the jebong knife, slightly modified for this special purpose. The bark of the gutta trees is thicker and rougher than that of *Hevea braziliensis*; it is, therefore, necessary to increase the length of the turned up part of the blade. It is also necessary to increase the radius of curve of this part of the blade in order to make a wider cut, for, if the bark of the tree is thick and the cut narrow, there is difficulty in collecting the gutta from the cut.

Yield.

The following are the results of various experiments in tapping by the method described above. In November and December, 1909, 100 trees of *P. oblongifolium*, having an average girth of about 33 inches, were tapped at the Waterfall, Taiping. The number of cuts to each tree was about 200. The average yield per tree was 1lb. 11 oz. of clean gutta. In this case the cuts were put five inches apart only: this was unnecessarily close and was a severe tax on the tree. In January and February, 1911, all the trees tapped in 1909 were again tapped, together with 223 new trees, having in all an average girth of 31 inches. These trees yielded $13\frac{1}{4}$ oz. each of clean gutta. Between November, 1911, and February, 1912, 235 trees having an average girth of 35 inches, produced an average of only eight ounces per tree; these trees included those tapped on the previous occasions. Between October and December, 1915, 398 trees having an average girth of 37 inches yielded 1 lb. 10 oz. of clean gutta per tree.

In the Rantau Panjang Forest Reserve in Selangor in 1913-14, 1,430 trees of *P. oblongifolium* were tapped, ranging from 18 to 45

inches in girth, the majority being well under 30 inches. The tapping of some of the trees was very lightly done, and although some of them were tapped a second time, the average yield per tree amounted only to four and a half ounces. Trees over 42 inches yielded an average of over 1 lb. per tree, and trees of 30 to 42 inches over half a pound.

In Trolak Forest Reserve, in 1913, 2,512 trees *P. oblongifolium*, over 18 inches in diameter, yielded 903 lbs. or five and three fourth ounces per tree. In the same Reserve, between September, 1915, and April, 1916, 3,166 trees of an average girth of 26 inches produced six and a half ounces per tree.

In connection with the work of tapping it should be borne in mind that it has always been carried out by coolies who are not accustomed to the work; the experiments should therefore be judged rather by the best results than by the worst. A labour force permanently employed on the same work would probably produce better results. From the figures given above it is estimated that a tree of 45 inches in girth should yield at least $1\frac{1}{2}$ lbs., and a tree of 30 inches three-quarters of a pound annually, if the tapping is carried out by a labour force trained to the work. Whether a tree of 20 inches girth should be tapped is open to doubt, for although it may produce a profit, it might be better economy to let the tree continue to develop to 25 inches or 30 inches before tapping it.

Cost of Tapping.

The cost of tapping depends largely upon the size of the tree. Two or more trees of 20 to 35 inches may be dealt with in a day by one tapper, whereas a tree of 50 inches may take two men a day to finish. Tappers are at present * paid 50 cents a day. It may be taken that the average cost will be 50 cents per tree, to which must be added 10 cents for supervision and implements. Taking the average annual production per tree at only 12 oz., the cost is 80 cents per lb. or $1.07 per kati, exclusive of cost of buildings, etc. *Taban* is valued at $2.30 per kati for purposes of export duty, and this may be taken as a fair price for ordinary gutta of good quality. The gutta obtained as here described is of the highest quality and is cleaner than the ordinary trade gutta. The Rantau Panjang gutta sold in Singapore realized $310 per pikul, and that from Perak $285 per pikul. The above estimates, which show a very substantial profit, are reasonably safe both as to cost of production and yield. The cost of production should be reduced when tapping is carried out regularly, and the yield can hardly be less.

The figures given above refer to *P. oblongifolium*. The yield of *P. obovatum* is greater, but the value is very much less. The figures at present available are insufficient to form any estimate of working.

The following table shows the yield of clean gutta from trees which have been tapped four times. It will be seen that there is no

* September, 1916.

general indication of a decrease in yield. The variations in the quantity obtained are probably due to the vagaries of individual tappers.

No. of trees.	1909.			1910-1911.			1911-1912.			1915.		
	Girth in inches.	Quantity obtained.		Girth in inches.	Quantity obtained.		Girth in inches.	Quantity obtained.		Girth in inches.	Quantity obtained.	
		lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.
3	45½	2	13	48	1	09	50	2	01	53	2	02
4	51	2	02	53½	2	06	56	2	05	56½	2	00
5	43¼	1	14	45	1	02	46	1	08	47¾	1	09
6	39¾	–	12	41¾	1	03	43½	1	00	49½	2	00
7	44	1	15	44¾	1	03	46¼	1	10	48½	1	04
8	51¼	–	09	53½	1	00	56	2	10	61	2	10
9	34¾	–	03	37½	1	08	39½	1	00	42	1	08
12	36¼	1	09	37½	–	15	38½	1	00	39¾	1	01
14	39½	1	02	40¾	1	08	42½	1	06	46¼	1	08
13	33¼	1	12	34½	1	06	36	1	01	40¼	1	00
15	51½	1	02	54	1	02	56½	1	00	61¾	1	10
17	26	–	12	28	–	13	29½	–	13	33½	1	14
23	51½	–	10	54½	1	12	57	1	14	61½	4	00
25	56½	2	13	60	2	08	62½	7	00	67½	3	60
26	64	2	14	65	2	14	72	2	10	74	2	88
27	52¾	3	02	55½	1	04	56½	1	00	58½	1	06
28	59	3	00	62	2	03	63	1	09	63¾	1	08
29	57½	3	02	60	1	10	61¾	1	14	64	2	02
20	52	1	15	54	1	13	55	1	02	58	2	00
34	51½	1	14	54	1	08	57	1	01	60½	2	00
42	60½	2	02	64	2	01	67	1	05			
43	49½	1	01	52	2	04	54	1	12	58	2	02
44	48¼	1	03	31	2	01	52½	1	15	56½	1	08
45	49¾	–	14	51¼	5	00	52	1	10	55	1	15
50	40	–	09	41	1	06	42½	1	02	47	1	09
49	34	1	03	35	1	02	35½	–	08	42	1	00
55	64¾	1	14	67	6	04	68	...		68¾	3	02
106	30	–	13	32½	–	14	33½	–	10	38¼	1	06
107	30¾	–	13	33	–	15	34¼	–	08	39	1	00
108	29¾	1	06	30½	1	01	31½	–	14	37	–	12
122	35½	1	15	37	1	05	38¾	–	14	44	1	02
121	29½	1	11	30½	1	10	33	–	07	39	1	00
128	22¼	1	00	26	–	15	27¾	1	07	32¼	1	00
124	42¼	2	03	44¼	2	04	46	1	10	49¾	1	07
129	23½	1	03	24½	–	08	26¼	–	08	35½	–	12
194	28¼	1	05	30½	1	00	31½	–	15	35	1	14
206	28¼	1	03	30	–	13	31½	1	06	34½	1	00
138	34¾	1	04	37	1	02	38¾	–	10	43¾	1	06

The questions that next present themselves are, how will tapping effect the tree? and, will the yield be maintained? As

regards the latter point we have no evidence beyond the tapping at the Waterfall, Taiping.

Effect of Tapping on the Trees.

It is not unreasonable to compare gutta with rubber in this respect. As far as is known at present, rubber trees of all kinds yield continuously, and we may reasonably hope that gutta trees will do the same having regard to the similarity of the two products. The trees appear to stand tapping on the system above described without suffering serious damage; the effect, of course, greatly depends upon the depths of the cuts, in the first experiment carried out at the Waterfall at Taiping, which was a severe test, several trees were killed, but on the majority of trees the cuts healed well. The treatment of the tree, as the tapping is now carried out is certainly severe. It may be modified, if it is found by experience to be too drastic, by tapping only one side of the tree at a time, or by placing the cuts further apart.

Extraction from the Leaves.

Gutta may also be obtained from the tree by extraction from the leaves. Many experiments have been made in extraction by chemical means, but the results have not been satisfactory, and a mechanical process is the only one now in practical use. This process is applicable only to the more valuable species, *viz. P, oblongifolium* and *P. borneense.* It is unsuitable to *P. obovatum.* The general principle of this system is as follows: The leaves while still fresh are chopped into small pieces in a machine much like a chaff-cutter, after which they are crushed to a pulp between rollers, cold water being added. The pulp is then treated with boiling water, during which process the dirt is separated from the gutta: this operation is usually repeated several times and the gutta that finally remains is pressed into blocks of any convenient size and shape. There are two factories which work in this way; the Netherlands Government Factory in Java, and that of the Netherlands Gutta Percha Company at Pasir Panjang, Singapore. Their methods vary slightly, but the principle in both cases is the same.

Dr. Tromp de Haas, the Netherlands Government expert, states that the leaves contain about five per cent. of gutta. As regards yield it was estimated that when in full bearing the Government Plantation at Tjepetir in Java would produce about 40 lbs. of gutta per acre annually, an allowance of 20 per cent. being made for loss of gutta in the process of extraction as compared with the percentage of gutta found by analysis to be present in the leaves. The quality of the gutta obtained by this system although good is inferior to that obtained from the stem, owing to the presence of chlorophyll, which it has hitherto been found impossible to separate.

Cultivation.

P. oblongifolium and *P. borneense* are the only species the cultivation of which has been tried on a large scale, and it is attended with considerable difficulties. Seed is not easily obtained in large quantities. Such seed-bearing trees as exist in the Federated Malay States are in or near forest, which makes it almost impossible to protect the fruit against the depredation of bats, birds, and squirrels, to all of which it is very attractive as a food. If the fruit were eaten and the seeds dropped on the spot little harm would be done, but this is not usually the case. Bats are the principal offenders, and these generally carry the fruit away from the tree before eating it. They consume the soft outer portion only and drop the seed. The seed thus dispersed is not necessarily wasted. In fact, in the forest reserves which are maintained for gutta-percha production, this is at present the chief means by which the stock is being increased. The seed deteriorates rapidly, and loses its germinating power in about two weeks.

Propagation by means of cuttings, layers, and marcots is difficult, and would be out of the question as a means of stocking large areas. Young plants are delicate and need careful treatment. They cannot stand continuous exposure to the sun, or the heating of the soil consequent on clean weeding: it is therefore necessary to raise them under shade. When once established in a favourable situation the tree is fairly hardy. It coppices very freely if exposed to full light. Where forest has been felled and burnt, it is not uncommon to find *taban* developed from stumps which have survived the burn.

The only existing plantation on a large scale is that at Tjepetir in Java at an elevation of 1,500 feet above sea level, where about 3,000 acres are under cultivation. The species cultivated are *P. oblongifolium* and *P. borneense*: these two are almost indistinguishable both in their structure and habit, and the quality of their gutta is the same. Gutta-percha is not indigenous to Java. The original plants were brought from Sumatra in 1883 and 1885, and it is from these trees that the large quantities of seed were obtained in 1900 to form the Tjepetir Plantation. The plants were raised in shade, and green manures were used. The plantation is intended principally to supply leaf gutta, and with this object in view close planting has been adopted, the distance being $4' \times 4'$, thinned later to $12' \times 12'$. All trees are topped at a height of 20 feet from the ground in order to check high growth and to encourage heavy crowns.

An experimental plantation of *P. oblongifolium*, about 40 acres in extent, has been established at Trolak in Perak. The plants were put out in the open, without shade, at distances varying from $6' \times 6'$ to $12' \times 12'$. The result of the experiment is so far not encouraging. Clean weeding was avoided in order to protect the

soil from excessive heating. Unfortunately, "lalang" grass (*Imperata cylindrica*, Beauv.) at once took possession of the ground, and the usual struggle followed, the lalang having the advantage, on account of the fact that it was desirable to eradicate it without unnecessary exposure of the soil. To *taban* as to most other crops lalang is fatal if left unchecked. Over a part of the area the trees are now fairly established, while on the remainder lalang is still a vigorous competitor.

Improvement of Natural Gutta-Percha Forests.

In view of the fine natural supply of gutta trees in the Federated Malay States forests it is not intended to extend plantations.

It has been proved by experience that a forest of pure *taban* can, if desired, be established by assisting the naturally sown seedlings in forest where the tree is fairly plentiful.

Systematic improvement of the *taban* forests was begun at Trolak in 1902, and in this reserve 4,861 acres had been treated up to the end of 1915, at a cost of $28,000, or $6.25 per acre for the actual work of improvement. The total expenditure on the reserve, which is 18,085 acres in extent, up to the end of 1915 was $55,850 inclusive of all charges. The present cost per acre of improved forest is, therefore, $11.49. As the area is extended the cost per acre will decrease, as the initial expenses for survey and buildings become spread over a larger area.

The work of improvement consists in going systematically through the forest and freeing all *taban* trees from any other growth which may be suppressing them, and from creepers. This operation has been repeated three or four times in some places. The results, as shown by the present appearance of the areas first treated, are most satisfactory, some parts of the forest being now composed of almost pure *taban*, and being well enough established to need little or no further treatment. The stock of trees per acre varies greatly. An enumeration made in 1914 over 678 acres in a part of the area first dealt with showed an average per acre of 72 trees of all sizes. Over the whole area the average would be less than this figure.

The following statement shows all areas treated under this system in the Federated Malay States up to the end of 1915:

Trolak Reserve	4,861	acres
Waterfall, Taiping	70	„
Behrang Reserve	2,191	„
Besout Reserve	1,202	„
Pulau Tiga Reserve	199	„
Rantau Panjang Reserve	2,918	„
Ulu Dong Reserve	2,079	„
Sungei Mangsok Reserve	323	„
Total ...	13,843	„

In nearly all these reserves there is a certain proportion of *P. obovatum* on the higher ground, but the work of improvement has been confined to the areas of *P. oblongifolium.*

Pests.

Both *P. oblongifolium* and *P. obovatum* are subject to the attacks of the caterpillar of *Rhodoneura myrtoea,* Drury, and *Ophiusa serva,* Fabre, but the latter has not, I believe, been observed in the Federated Malay States. *Rhodoneura myrtoea* both eats the leaves, and also damages them by rolling itself in them when in the larval stage. A leaf gall of the order *Psyllidae* is frequently found on mature trees, but it appears to do no harm. If the leaves are to be depended upon as a source of gutta, the depredation of *Rhodoneura* may become a serious matter in pure plantations. It has appeared on the Tjepetir Plantation on several occasions, but it has not at any time affected the whole area, nor has the damage been extensive.

Seeing that the cultivation of gutta is attended with so many difficulties and that there must be a long period of waiting before the trees come into bearing, it is unlikely that private enterprise will develop plantations, unless in connection with some other industry which is entirely dependent on gutta. It therefore devolves upon the Government to take such steps as are necessary to maintain the supply, and it is from the State natural gutta forests, improved by sylvicultural treatment, that future supplies for the open market will chiefly come. It may be accepted as proved that the works of improvement, which have been carried out in these forests, have been successful, and that the cost has not been excessive. It would, therefore, seem sound policy to extend the work as soon as possible to all the best natural forests in the Federated Malay States.

Note.—In 1897 Dr. Eugene Obach delivered before the Society of Arts a course of three lectures on Gutta-Percha in which the subject was very fully treated in the light of experience to that date. The lectures were published in the proceedings of the Society of Arts, printed by W. Tronnee, 10 Gough Square, Fleet Street, E.C. In this article, use has been made of some of the facts recorded in the lectures.

VULCANIZATION CATALYSTS.

By B. J. Eaton.

IN view of the results obtained in our rubber vulcanization researches, in which it has been shown that the variability of plantation Para rubber consists principally in differences in rate of vulcanization and that these differences are caused by the variable proportion of a natural catalyst or accelerator in the raw rubber produced in the coagulum by a degradation of the protein or nitrogenous constituents of the latex, a resumé of the nature and action of rubber vulcanization catalysts should be of interest. The information on the subject given in this paper is derived from a communication in the *India Rubber Journal,* Vol. LII, No. 13 of 23rd September, 1916, by Andrew H. King.

In the first instance it may be necessary to explain the meaning of the term "catalyst" as used in chemical nomenclature. A catalyst or catalyser (or "accelerator" as it is frequently called in rubber technology) is a substance, which, while it undergoes no change itself, (or more correctly, is the same before and after a reaction) alters the velocity of certain chemical reactions or combinations, so that these can be carried out at a greater speed, or at a lower temperature or more completely than in the absence of the catalyst.

A catalyst is unable to initiate a chemical reaction, but only to modify its velocity.

Very small quantities are capable of transforming large quantities of the reacting substances. Catalysts may act in two ways, by accelerating or retarding a reaction—*i.e.*, positively or negatively. Catalysers of both kinds are known in the manufacture of rubber.

Although it has been stated that catalysts remain themselves unchanged during a reaction, this is probably not strictly true, especially in the case of some of the catalysts employed in the rubber industry. These substances probably form intermediate compounds with one of the reacting substances—*e.g.*, with sulphur in the vulcanization process, that is, the catalyst acts as a sulphur carrier, the compound formed is then broken up again and the sulphur from the compound taken up by the rubber molecule itself.

Ostromyslenski, a Russian chemist, has brought forward certain evidence in support of the theory that organic vulcanization catalysts are substances which can form thiozonides with sulphur—*i.e.*, substances in which the sulphur is combined with itself as oxygen in ozone, represented chemically by the formula $-S-S-S-$.

The importance of catalysts in the rubber industry is obvious, and is attracting considerable attention at the present time, owing to the necessity of speeding up vulcanization, in order to turn out rubber goods with rapidity.

It is also interesting to note that organic vulcanization catalysts began to attract attention first in connection with the production of synthetic rubber, the difficulty of vulcanization of which I have referred to before, a difficulty which is obviously a great drawback to its use and one which adds to the cost in the manufacture of vulcanized articles. Soon after, these catalysts were utilized in connection with natural rubbers.

The speed of reaction is influenced in proportion to the amount of the accelerator used, up to a certain limit, and this is obviously so in the case of the natural accelerator produced in raw Para rubber under suitable conditions.

Another interesting feature of catalysts is that with a combination of catalysts the resulting increase of speed of the reaction is greater than the sum of their individual increases, when acting alone.

Before dealing with rubber vulcanization catalysts, it may be of interest to quote the commercial utilization of a catalyst which has had a great influence in the chemical industry. I refer to the contact process for the preparation of sulphuric acid, which depends on the reaction between sulphur dioxide and oxygen and the combination of these in the presence of platinized asbestos (the catalyst) to produce sulphuric acid.

Another instance which is of interest to planters of oil-bearing plants, such as cocoanuts, is the use of another catalyst, in the form of finely divided nickel, which aids the combination of hydrogen with certain liquid oils, converting them into solid fats of greater commercial value, a discovery which has and will have a very important bearing on the fat and oil industry.

Mineral Accelerators.

The use of mineral accelerators in the rubber industry is of long standing, the chief accelerators being lime, magnesia, litharge, lead oxide, white lead and zinc oxide.

Lime.—In soft rubber from $\frac{1}{2}$ to $2\frac{1}{2}$ per cent. is said to be used.

Magnesia.—The heavy calcined oxide known as "Magnesia Usta" is used: magnesia, although not as strong an accelerator as lime is more extensively used, since lime has a hardening effect on rubber.

Litharge and lead compounds.—Litharge, white lead, sublimed white lead and red lead are all used as accelerators, but their use is limited, owing to the fact that rubber prepared by their use is black and has a high specific gravity.

Stevens is of the opinion that the catalytic effect of litharge is due to the heat liberated by reaction between the litharge and sulphur, so that the actual temperature in the mixture is higher than the temperature of the autoclave in which the vulcanization is taking place. (Increase of temperature in the vulcanization process, increases the speed of vulcanization.)

Red lead is more active than litharge, but is not used, on account of its oxidizing properties. White lead (basic lead carbonate) is also used.

Zinc oxide.—This substance has only a slight accelerating effect, and considerable quantities can be mixed with rubber; it has a powerful toughening effect.

Miscellaneous mineral substances.—Iron oxide (3 to 8 per cent.) is said to have a catalytic action, but can only be used in brown goods. Manganese oxide and cuprous (copper) oxide are both good accelerators but, unfortunately, both have a very deleterious effect on rubber. Molybdenum sesqui-oxide is an accelerator in quantities over 10 per cent.

Alkalis.—The alkalis, sodium and potassium hydroxides and their carbonates are powerful accelerators in certain proportions, beyond which they act negatively—*i.e.*, retard vulcanization.

The use of alkalis has been dealt with in previous bulletins (*vide Agricultural Bulletin*, Vol. IV, No. 2, November, 1915, and Vol. IV, No. 6, March, 1916) and the subject has been treated by Martin of the North British Rubber Co., and others. The use of alkalis is of importance in connection with the reclaiming of waste rubbers.

Alkalis are said to act as accelerators up to $\frac{1}{2}$ per cent., beyond which they retard, while at 5 per cent. the mixture is almost incapable of being cured. Nickel oxide is a negative catalyst and vulcanization can be entirely prevented by its use.

No mention is made, in the article from which most of the facts are derived, of the probable negative or retarding effects of the mineral acids, hydrofluoric, sulphuric and hydrochloric acids or of alum. Secondly, whether these negative accelerators may be considered strictly as such, or whether they have an influence on the natural accelerator present in raw rubber and retard vulcanization on this account, does not yet appear to have been proved.

Organic Accelerators.

Chief interest during the last two or three years has, however, been centred round the numerous recently discovered organic accelerators, which dates, as stated above, from the discovery of synthetic rubber by the more recent satisfactory methods. Synthetic rubbers cannot be vulcanized satisfactorily without the use of organic catalysers and their application to natural rubber has been

attended with successful results. It may be stated that synthetic rubber and many plantation Para rubbers suffer from extreme cleanliness or purity. We are, as I have stated elsewhere, removing from our rubber, substances which nature intended should be present and if these substances are removed, it is necessary in many cases to substitute them by other substances artificially prepared, which usually add to the cost of manufacture. (At present, many of these organic accelerators are very costly.)

As our researches have shown, one of the chief catalysts present in raw rubber is related to the proteins in the latex and is a degradation product of the proteins produced usually by the action of micro-organisms which enter the latex from the air (*vide Journal, Society of Chemical Industry*, Vol. XXXIV, No. 19, 15th October, 1915, and Vol. XXXV, No. 13, 15th July, 1916, also *Agricultural Bulletin*, Vol. III, No. 4, February, 1915, and subsequent numbers during 1915 and 1916).

All organic accelerators are said to contain nitrogen and many have amino groups. The function of the nitrogen would therefore appear to be of considerable importance.

Only three generalizations appear to hold good at present: (1) According to Ditmar all organic bases having dissociation constants greater than 1×10^{-8} act as catalysers; (2) At present only organic substances containing nitrogen are known to be accelerators and nitrogen would therefore appear to be essential; (3) According to Ostromyslenski, only those compounds capable of forming thiozonides with sulphur act as accelerators. A rubber vulcanizing catalyst should be preferably a solid and capable of being finely pulverized, so that it can be thoroughly mixed with the rubber and it should have a high boiling point so that it is not vaporized during vulcanization at the high temperatures employed.

An interesting point observed by the writer, when using volatile accelerators (*e.g.*, piperidine) was the volatilization of the accelerator from the mixture containing it, and its migration into a control mixing laid on top of a mixing containing 1 per cent. of the accelerator. The control, when freshly made, behaved in the usual manner, but after lying for several days on top of the mixing containing the accelerator, it was found that one side of the control mixing was over-vulcanized while the other was under-vulcanized at a certain temperature, due to the volatilization of the accelerator into the control mixing.

The following organic compounds are stated to be powerful catalysts:

1. Carbon bisulphide addition products with—
   (*a*) Aniline, (*b*) Dimethyl aniline, (*c*) Tetrahydropyrrole (*d*) Dimethylamine.

2. Ammonium compounds—
   (*a*) Ammonium borate, (*b*) Aldehyde ammonia (*c*) Quaternary ammonium bases.
3. Amino compounds—
   (*a*) Para-phenylenediamine, (*b*) Tetramethylenediamine, (*c*) Sodium amide, (*d*) Naphthylene diamine, (*e*) B. B. dimethyl Δ methyltrimethyleneimine, (*f*) Trimethyleneimine, (*g*) Benzylamine.
4. Piperidine and derivatives—
   (*a*) Piperidine, (*b*) Methyl piperidine.
5. Quinoline and derivatives—
   (*a*) Quinoline, (*b*) Quinoline sulphate, (*c*) Quinosol, (*d*) Sulphuroxyquinoline.
6. Miscellaneous—
   (*a*) Anthraquinone, (*b*) Urea derivatives, (*c*) Formanilides, (*d*) Albumens.

The constitution and methods of preparation of some of these compounds is given in the article from which most of this information is derived. A number of these substances have been prepared and patented by the well known German chemical firm of Bayer and Co. Piperidine was among the earliest of these organic accelerators to be patented by Bayer and Co. in 1912, and it was intended to be used for synthetic rubber, and proved so successful that it was tried with natural rubber. A mixture of 100 parts of Para rubber, 10 parts of sulphur and 0.5 parts of piperidine is perfectly cured in 15 minutes at 53 lbs. steam pressure. This result is very similar to results obtained by me, in which a good cure of a crepe rubber normally requiring about $3\frac{1}{4}$ hours was obtained in $\frac{1}{4}$ to $\frac{1}{2}$ an hour, with 10 per cent. of sulphur and one per cent. of piperidine, vulcanized at about 40 lbs. steam pressure (140° C.).

The value of these organic accelerators lies in the fact that they can be used for both soft and hard rubber articles, whereas the mineral accelerators can only be used for hard rubber articles.

Albumen.—The use of albumens, which covers the direct addition of proteins to rubber, was first patented by a German rubber chemist (Esch) in 1912, who used a paste containing egg albumen (15 parts) with calcium hydroxide (slaked lime) or magnesium hydroxide (two parts). Low grade rubbers are said to be considerably improved. (N.B.—Whether egg albumen will act alone as an accelerator or whether the lime or magnesia causes a degradation of the proteins during vulcanization, forming a catalyst similar to that produced by us by the biological decomposition of proteins, does not appear to have been investigated.) We have found, in confirmation of previous work by Beadle and Stevens that peptone behaves as a mild accelerator, whereas, in contradiction of the

results obtained by the same workers, casein (the protein from milk) had no effect.

At present, apart from the three generalizations mentioned, there is no theory which covers the action of these catalysts and more facts are required. The work carried out by various experimenters in connection with the use of these catalysts and the information which we have obtained from the chemists and manufacturers of rubber works both in Great Britain and America, on the variability of plantation rubber in respect to rate of cure, goes far to confirm the theory advanced from our laboratory as to the cause of variability in rate of cure of plantation Para rubber and can probably be applied also to rubbers other than Para.

One interesting substance, to which reference is made in the article under review, is putrescine or tetramethylenediamine, a natural product of protein decomposition, produced during the putrefaction of animal matter such as flesh. It appears highly probable that the decomposition of latex proteins produces a substance of this nature, which is a more powerful accelerator than the catalyst produced from the animal proteins. Our researches, for example, have shown that the decomposition of latex proteins does produce a more powerful accelerator than is obtained by a similar decomposition of the animal protein—casein.

EUCALYPTUS IN THE FEDERATED MALAY STATES.

By J. N. Milsum.

A LETTER recently appeared in the *Malayan Tin and Rubber Journal*, Vol. V, No. 19, page 22, suggesting that an attempt be made to grow the *Eucalyptus* tree in this country for the purpose of timber supplies.

An article dealing with the cultivation of the *Eucalyptus* tree in Singapore Island is to be found in the *Agricultural Bulletin S. S. and Federated Malay States*, May 1912, page 145, in which the writer terminates with the following statement: "One must perforce come to the conclusion that the Eucalypts (with rare exceptions) are not suited to our climate, and taken for granted that all the useful and healthful effects which are attributed to the Eucalypts, in so far as influence on climate is concerned, be perfectly true, I think it has been proved conclusively that the tree will not grow in sufficient quantities to warrant further trials."

The following extract from the same article refers to the condition of several Eucalypts in the Singapore Botanic Gardens in 1912. "Some six or seven years ago, Mr. Ridley selected the driest part of the Garden for Australian plants; *Callistemons*, *Grevilleas*, *Acacias* and three Eucalypts were planted therein. The present condition of those Eucalypts is as follows: *E. citriodora* is now about fifteen feet high, of slender growth, the lower branches continually dying off and altogether not in a very healthful condition; *E. gomphocephala* is now about eight feet high and in a similar condition to the last; *E. robusta* on the other hand, as the name implies, is of more robust growth. The specimen is now about eighteen feet high and in this case, the lower branches remain on the plant for a much longer period than on any of the other two. It is the most healthy specimen of the three and it will be interesting to note its future growth.

It will be seen, therefore, that little or no success has resulted in the endeavour to establish Eucalypts in Singapore."

It was decided last year by the Department of Agriculture, Federated Malay States, to obtain seed of *Eucalyptus* and attempt the cultivation of these trees in the Experimental Plantations, Kuala Lumpur. On the application of the Director of Agriculture, Federated Malay States, seed of several species of *Eucalyptus* were received from the Director, Botanic Gardens, Sydney, in January of this year.

The following list shows the species received and their principal characters and uses in Australia.

Eucalyptus bicolor. A. Cunn. Black box. A tree rarely attaining a height of 100 to 150 feet, but usually only a shrub. Uses of wood unknown.

E. crebra. F. v M. Narrow-leaved ironbark. A slender tree 100 feet high. Wood durable under ground. A valuable timber tree.

E. rostrata. Schl. Red gum. A tree sometimes 200 feet high, and 6 to 12 feet in diameter. It prefers low, moist, clayey soils, but can stand much heat. Of rapid growth. Wood durable in the soil and water. Makes good fence posts and piles. It resists the attacks of white ants. It is used for ship building and is an exceptionally good fuel wood.

E. populifolia. Hook. A tree height 40 to 50 feet. Uses of wood unknown.

E. melanophoia. F. v M. Silver-leaved ironbark. A small tree; leaves, glaucous or mealy white. Uses of wood unknown.

Seed of the following two species was purchased from the Salkia Nursery, Howiah, India at the same time.

Eucalyptus citriodora. Hook. Lemon-scented gum. A rapid-growing tree sometimes 125 feet high and 4 feet in diameter. Wood flexible, strong and durable.

E. globulus. Labill. Blue gum. Sometimes 200 to 300 feet high with a diameter of 10 feet or more. The fastest growing and best known tree of the genus. The wood is among the stronger *Eucalyptus* timbers and is used for many purposes, it is said, however, not to be suitable for underground work but is much used as fuel and in the manufacture of implements.

The seeds were sown during the first week in January of this year. Two methods were adopted. In one instance the seeds were sown in carefully prepared beds in the nursery and though the seed germinated satisfactorily within a week or so, few plants were raised owing to the seedlings damping off or dying during transplanting. It would appear that seedling Eucalypts are very sensitive to the humid climate of this country, and it is of little use attempting to raise them in nursery beds. Better results were obtained by sowing the seed in pots and boxes, though again considerable numbers of seedlings were lost from the same causes. A few seedlings of each species were, however, successfully established in bamboo baskets. During the damp cloudy weather experienced in February last, numbers of the seedlings were killed by the fungus causing "damping off."

In May, a commencement was made to plant out the largest trees as specimens in the Public Gardens, Kuala Lumpur; the remainder were potted into large pots and placed in full sunshine.

The following table shows the condition of the *Eucalyptus* trees in the Public Gardens at the present time. The garden number is appended in each instance for future reference.

Garden No.	Name.	Date planted.	Present height.	Remarks.
			ft. in.	
1	*E. rostrata* ...	May, 1916 ...	7	Growing well.
2	*Do.* ...	June, 1916. ...	6 10	„
3	*Do.* ...	July, 1916 ...	10	„ , a fine tree.
4	*E. citriodora*	August, 1916	5 6	Growing well.
5	*Do.* ...	„	7 9	Growing and branching well.
6	*E. melanophoia*	7th Sept., 1916	6 3	Growing well.
7	*E. bicolor* ...	6th Oct., 1916	5 3	„
8	*E. rostrata* ...	„	7	„
9	*Do.* ...	„	7	„
10	*E. citriodora*	„	5 3	„
11	*E. rostrata* ...	24 Oct., 1916	6 6	„
12	*E. melanophoia*	„	4 6	„

All these *Eucalyptus* trees appear to have become well established and so far are making good growth. Their future behaviour will be published at a later date in the *Agricultural Bulletin.*

The following table shows the seedlings that are at present being grown in pots; these will be planted out in favourable positions and their rate of growth similarly recorded.

Name.	Number of seedlings.	Maximum height.	Remarks.
		ft. in.	
E. rostrata ...	70	6 6	The fastest and strongest grower
E. citriodora ...	5	6	Growing well
E. bicolor ...	1	2 8	Weak growth
E. populifolia ...	10	2 6	„
E. crebra ...	10	1 6	„
E. globulus ...	1	1 6	Weak growth and very unhealthy appearance
E. melanophoia	2	4	Fairly strong growth
E. microtheca ...	2	5	„ „

It will be seen from the preceding tables that the greatest success has been obtained with the Red Gum (*E. rostrata*). This

species so far appears to be amenable to the climate of the plains of the country. The Lemon-scented Gum (*E. citriodora*) also is growing well. The Blue Gum (*E. globulus*), however, has not grown well, and there is little doubt that this species is unsuited for this climate. It has been unnecessary to give much attention to these seedling Eucalypts beyond keeping them well staked, as they are liable to be broken by the wind during the early stages of their growth.

The writer is of the opinion that certain species of *Eucalyptus* might successfully be grown on the hills of this country. It is intended to have a representative collection of those species which have been raised from seed this year, planted out at various attitudes at the Experimental Plantation, Gunong Angsi, Negri Sembilan.

It is interesting to note that two *Eucalyptus* thought to be *E. citriodora*, raised from seed in the Experimental Plantation, Kuala Lumpur, in 1914, have attained a height of 40 feet, and a girth of 14 inches at six feet from the ground. These two trees are growing in the original seed beds, and have made rapid growth and at the present time look very healthy. It is unfortunate that some uncertainty exists as to the correct nomenclature of these two trees, should they flower, it would probably be possible to identify them.

In conclusion, the writer would emphasise that not only is there a great difficulty experienced in raising *Eucalyptus* from seed, at any rate on the plains in this country, but also that the humid atmosphere would probably be unsuited for most species, as the behaviour of the trees in Singapore Gardens indicate. Whether more favourable results will attend the present experiments remains to be seen.

THE COAGULATION OF LATEX IN THE PRESENCE OF SUGARS.

By B. J. Eaton.

IN continuation of the work carried out by Grantham and the writer on the natural coagulation of Hevea latex in the presence of various sugars which, it will be remembered, was shown to be due to fermentation set up by certain organisms which gain entrance to the latex from the air during and after collection, the investigation of this problem has been carried to a further stage by Drs. Gorter and Swart of the West Java Rubber Testing Station and the following is an abstract of the results obtained by these workers, published in Bulletin No. 6.

The writers, after referring to the recent high cost and difficulty in obtaining acetic acid in Java, which has necessitated a more vigorous search during the last year for suitable substitutes for this acid, postulate the three possible methods of coagulation of Hevea or other latex as follows :

1. Coagulation as the result of physical agencies—*e.g.*, smoking, evaporation of latex and electrical coagulation.
2. Chemical coagulation by acids, salts, etc.
3. Coagulation by means of micro-organisms or enzymes.

Until quite recently the last-named method remained untried.

Whitby, chemist to the Société Financière, was the first to publish any investigations on the natural coagulation of Hevea latex, under different conditions, and attributed the coagulation to the possible presence of a coagulating enzyme. Further investigations by Grantham and the writer showed that the coagulation was almost certainly due to micro-organisms (*vide Agricultural Bulletin*, Vol. IV, No. 2, November, 1915) those which coagulate being favoured by the addition of sugars to the latex.

Drs. Gorter and Swart agree with the conclusions arrived at by us, and state that they have also proved by experiment that if sugar is added, this is converted shortly into lactic acid, a result which was anticipated by us, but not proved.

These workers took two litres of latex to which six grammes of sugar dissolved in 0.5 litre of water was added and allowed the mixture to stand 24 hours, obtaining complete coagulation without any trace of decay. The spongy coagulum was pressed and yielded 650 ccs. of clear serum, which was made alkaline with baryta water, the excess of barium hydroxide being precipitated by passing carbon dioxide through the liquid, and the liquid filtered and evaporated and rendered acid with phosphoric acid and distilled. The distillate required 90 ccs. of N/10 alkali for neutralization corresponding to 0.54 grammes of acetic acid. The non-volatile acids were then

removed by repeated shaking with ether, and on distillation a syrupy residue, which subsequently yielded a small quantity of crystalline material, was obtained. The liquid acid separated from the crystals was again dissolved in water and made up to 100 ccs.: 10 ccs. of this solution took 15.3 ccs. of N/10 alkali for neutralization. The total quantity of acid therefore present was 1.38 grammes calculated as lactic acid.

The liquid was shown to contain lactic acid by the yellow colouration with iron chloride and by the formation of zinc lactate, on treating the acid liquid with zinc oxide, filtering and evaporating the solution to separate the crystals of zinc lactate.

The figures obtained show that more lactic acid than acetic acid is formed during the fermentation, the latter not being more than one quarter of the whole. There is also, as stated above, a small quantity of a crystalline acid obtained, which was purified by solution in hot water, from which it crystallizes on cooling. This acid melted at 183° C. and when mixed with succinic acid, the melting point was not lowered, proving that the crystals consisted of succinic acid. This acid is a bye-product of the alcoholic fermentation which takes place simultaneously in the latex. The alcohol formed from the sugar is, therefore, transformed partly into acetic acid by acetic acid fermentation. The fermentation is, therefore, a complicated one and Drs. Gorter and Swart state that our interests are concerned chiefly with the acids formed, as they attribute the coagulation to the resultant acidity.

The amount of acid formed, depends partly on the amount of sugar present and also on the fact that when a certain proportion of acid is formed, subsequent fermentation of the sugar to acid is prevented, owing to the action of the acid on the acid-forming bacteria. Thus there is a fixed maximum acidity in the latex which cannot be exceeded even with sufficient excess of sugar. If calcium carbonate be added in order to neutralize the acid as formed, fermentation continues unimpeded. This, however, is of no practical importance as the free acid itself is required for coagulation.

The method of neutralization of the acid, however, enables the study of the fermentation be carried further. The fermentation is said to continue under these conditions even at 45° C. and the lactic acid fermentation becomes even more important, as lactic acid organisms, in contradistinction to other organisms, predominate at this high temperature.

The following experiment was carried out :—To 100 ccs. of serum, prepared as above, 200 ccs. of water, 15 grammes of sugar and 5 grammes of fine calcium carbonate were added and the mixture allowed to stand for five days at 45° C. By this time, the chalk has nearly completely disappeared, which shows that about nine grammes of lactic acid must have been formed.

In the same way, by evaporating the filtered liquor, 12 grammes of crystallized calcium lactate is obtained. The residual liquor distilled with phosphoric acid gave an acid distillate which on evaporating with barium hydrate and removal of excess of barium with carbon dioxide yielded 0.27 grammes of dry barium salt which on exposure to air passed into a crystalline mass increasing 0.019 grammes in weight, corresponding with the absorption of one molecule of water. The quantity found corresponds to 0.120 grammes of acetic acid so that the proportion of acetic to lactic acid is about 1 to 7 or 8.

On treating the calcium lactate with phosphoric acid and shaking with ether, the pure acid was obtained as a syrupy liquid which would not crystallize. On treating with zinc oxide in aqueous solution, the zinc salt was formed, and this was shown to be the inactive lactic acid.

The water of crystallization and the proportion of zinc oxide found by analysis agreed with the composition of zinc lactate containing three molecules of water.

On fermentation at 45° C. in the presence of chalk (calcium carbonate) some alcohol together with traces of acetone and formic acid were found, substances which as a rule are bye-products in lactic acid fermentation.

In the slow coagulation of latex with acetic acid in minimum quantities, which is becoming more general, lactic acid, according to these workers can also be shown to play an important part in assisting the acetic acid to coagulate the latex.

It was shown that in one litre of latex, to which not more than 0.3 grammes of acetic acid had been added, after standing for 24 hours, 0.80 grammes of lactic acid was produced.

It is concluded that among the organisms which enter the latex after it leaves the tree, given favourable circumstances, the lactic acid fermenting organisms soon predominate, whereas on the surface where air can easily penetrate, putrefactive bacteria are predominant. The lactic acid bacteria produce lactic acid from the sugars present and the putrefactive bacteria produce alkaline substances from the nitrogenous constituents. The lactic acid also helps the lactic acid bacteria to develop at the expense of the other organisms. According to Drs. Gorter and Swart, latex contains about 2.3 grammes of sugar per litre, which is too little to help the lactic acid ferments in competition with other organisms and the addition of sugar provides the shortage essential to enable the lactic acid organisms to produce rapidly sufficient acid to destroy or inhibit the action of the other bacteria. Our own results to the effect that the coagulation is assisted by exclusion of air have been confirmed.

Estate Experiments with Sugar Process.

Our own conclusions that 0.2 per cent. of sugar was the minimum amount for perfect coagulation have been confirmed. Good results were obtained with three grammes per litre of thick latex to which 20 to 25 per cent. of water had been added. Drs. Gorter and Swart for large quantities recommend the following :

Latex	175 litres	=	38.5 gallon.
Water	50 „	=	11 „
Sugar	400 to 450 grammes ...	=	14-16 ozs.

The sugar is dissolved in the water and added to the latex which is then well stirred. Coagulation should be complete in about 18 hours. With only 300 grammes of sugar for similar quantities of latex, complete coagulation was not obtained. With excess of sugar, as would be expected from the nature of the process, coagulation is not hastened, as it would be by chemical coagulation processes—*e.g.*, coagulation with acetic acid, since the acids produced are formed slowly. The authors also tested the influence of the previous day's serum on the rate of coagulation and acid formation but did not obtain the results they anticipated.

The following is the result of a few experiments :

(1) 1 litre of latex + 200 ccs. of water + 3 grammes of cane sugar. 100 ccs. of the serum from the above contained after 24 hours 42 ccs. of N/10 acid corresponding to 2.5 grammes of acetic acid per litre. Coagulation was perfect in eight hours.

(2) 1 litre of latex (rubber content 33.5 per cent.) + 200 ccs. of serum from Experiment (1) + 3 grammes cane sugar. 100 ccs. of serum after 24 hours corresponds to 3.2 grammes of acetic acid per litre. Coagulation still imperfect after eight hours. Serum milky.

(3) 1 litre latex (rubber content 33.3 per cent.) + 200 ccs. of serum of Experiment (2) + 3 grammes cane sugar. 100 ccs. of serum correspond after 24 hours to 3.2 grammes of acetic acid per litre. Perfect coagulation in eight hours.

The limit of acidity is, therefore, reached after a single addition of serum, without more rapid coagulation. Similar results were also obtained from a large experiment under otherwise similar conditions, and serum alone was unsatisfactory.

The results of the addition of serum in this form are, therefore, not satisfactory.

On estates on which experiments were carried out, the yellow layer of decay was always found in the sugar process, when the coagulation was carried out in open vessels. When serum was added, the decomposition was absent but the surface was grey, violet or reddish, due to oxidation. The disadvantages of the process due to

discolouration of the rubber and the fact that only crepe can be prepared by this method are also discussed. It is also pointed out that with sugar at 15 fl. per pikul, the cost is half that of acetic acid at fl. 50 per kilogramme. (Experiments carried out in our laboratories at Kuala Lumpur show that the rubber is in every respect equal to acetic acid coagulated samples and has a tendency to vulcanize faster.)

Addition of Sodium Bisulphite.

With 0.5 grammes of sodium bisulphite per litre of latex and the same proportions of sugar as before, perfect coagulation was obtained, but with double the quantity of bisulphite, the coagulation was incomplete. Coagulation was also obtained with 0.7 grammes of sodium bisulphite per litre, the acid nature of the sodium bisulphite appearing to aid the acid fermentation. On a large scale, results with sodium bisulphite were unsatisfactory.

Experiments carried out by me at Kuala Lumpur show that a crepe of excellent colour can be prepared by coagulation in the presence of sugar in a closed vessel and subsequently soaking the coagulum for 24 hours in a five per cent. solution of sodium bisulphite, as is done in the case of "lump" rubber or cup coagulation. The exclusion of the air in the first instance prevents any preliminary darkening due to oxidation.

Coagulating Agents for Sheet.

The latter part of the same bulletin by Drs. Gorter and Swart deals with the use of various coagulants for making sheet.

The use of various acids is discussed and the possibility of their ultimate effect on the rubber.

Hydrofluoric acid, sulphuric acid and alum are not recommended, especially in the manufacture of sheet, where a portion of the acid or salt is retained by the rubber, and in view of the experiments carried out at the Agricultural Department, Kuala Lumpur.

Fermented Coconut Milk.—Experiments with the milk of young coconuts showed that these contained as much as 5 per cent. of sugar from which a liquid containing 2.5 per cent. of acetic acid was anticipated. The acid content was measured from time to time and was found to be only 0.4 per cent. after seven days and only 0.46 per cent. after 15 days. It was also found that only about half the acid was acetic acid and the remainder lactic acid which is known to be harmful to acetic acid bacteria, hence probably the inhibition of the development of the acetic acid fermentation.

Exports of Rubber from British Malaya (other than the F.M.S.).

State.	Month.	Quantity.
		lbs.
Johore	August	25,308
Kelantan	,, ...	...
Kedah	July-August ...	459,461⅓
Perlis	August	1,855⅔
British N. Borneo ...	,, ...	401,657
Brunei	,, ...	25,036

Exports of Rubber from British Malaya (other than the F.M.S.).

State.	Month.	Quantity.
		lbs.
Johore	September	...
Kelantan	,, ...	...
Kedah	August-September ...	815,254⅓
Perlis	September	2,286⅔
British N. Borneo ...	,, ...	374,057
Brunei	,, ...	8,710

Abstract of Meteorological Readings in the various Districts of Malaya for the month of September, 1916.

District.	Mean Barometrical Pressure at 32° Fah.	Maximum in Sun.	Temperature.				Hygrometer.				Prevailing Direction of Winds.	Total Rainfall.	Greatest Rainfall during 24 hours.
			Mean Dry Bulb.	Maximum.	Minimum.	Range.	Mean Wet Bulb.	Vapour Tension.	Dew Point.	Humidity.			
Kelantan, Kota Bahru	...	135.	82.1	91.96	73.23	18.73	77.0	.826	73.5	75.	...	7.69	1.60
Pahang, Kuala Lipis	...	...	81.6	90.7	72.6	18.6	76.5	...	...	...	...	4.06	1.50
Johore, Johore Bahru	...	...	...	87.78	73.53	14.25	...	...	...	...	...	6.36	...
Singapore, Kandang Kerbau ...	29.768	159.	83.6	88.4	75.0	13.4	78.1	.880	...	77.	...	6.15	1.28
Malacca, Durian Daun	29.779	145.4	82.3	86.7	72.0	14.7	78.5	.932	...	85	S.E.	9.87	4.02
Negri Sembilan, Seremban ...	...	158.	79.0	89.8	70.8	18.9	75.2	.797	72.3	81.1	N.W.	3.08	1.10
,, Kuala Pilah ...	...	143.8	82.1	90.9	71.9	18.8	78.7	.925	76.6	83.5	...	2.32	1.02
,, Port Dickson...	...	126.7	82.	87.5	74.2	13.2	77.3	.847	75.6	77.7	...	5.84	2.43
Selangor, Kuala Lumpur ...	29.750	143.2	80.4	84.3	76.9	7.4	77.0	.819	74.8	82.	S.W.	2.37	.67
,, Klang...	...	...	80.5	86.2	73.9	12.3	76.6	...	...	...	...	3.26	.76
,, Kuala Selangor ...	...	...	...	88.9	74.8	14.1	...	...	...	...	...	4.27	3.04
,, Rawang	...	...	...	93.3	...	...	...	...	...	...	...	1.36	.57
Perak, Telok Anson	...	...	82.42	92.	70.	22.	77.53	.880	...	81.	...	7.08	1.49
,, Ipoh	...	...	82.78	94.	70.	24.	76.77	.839	74.36	75.	...	5.55	1.67
,, Taiping	...	114.	82.34	94.	72.	22.	77.30	.871	...	79.	...	10.47	2.99
,, The Cottage	...	...	...	...	...	...	...	...	...	...	...	19.48	2.16
,, Parit Buntar	...	...	83.61	94.	65.	29.	78.16	.892	...	79.	...	3.64	1.18
Penang Georgetown	29.787	145.2	83.2	88.9	73.6	15.3	77.4	.862	...	76.4	S.E.	3.83	1.00
Kedah, Alor Star	...	...	...	...	...	...	...	...	...	...	...	7.15	1.90
Perlis, Perlis	...	...	...	88.66	74.03	14.63	...	...	...	...	...	8.85	5.29